Converged Broadband Networks: Public Policy Implications

Marvin A. Sirbu
Professor of Engineering and Public Policy
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213
email: sirbu@cmu.edu

© 2004 Marvin A. Sirbu

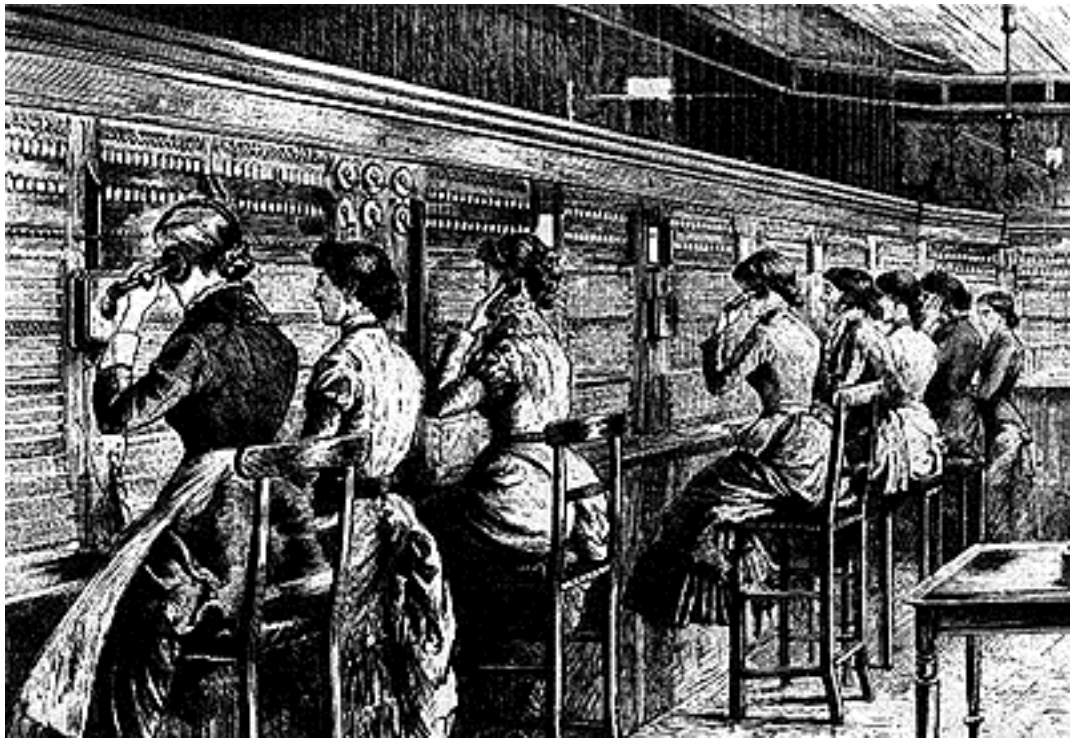
Outline

- Legacy Networks
  - Circuit Switching
  - Cable Television
- Packet Switching
- Broadband networks and service convergence
- Regulatory problems posed by the convergence

© 2004 Marvin A. Sirbu

Circuit Switching

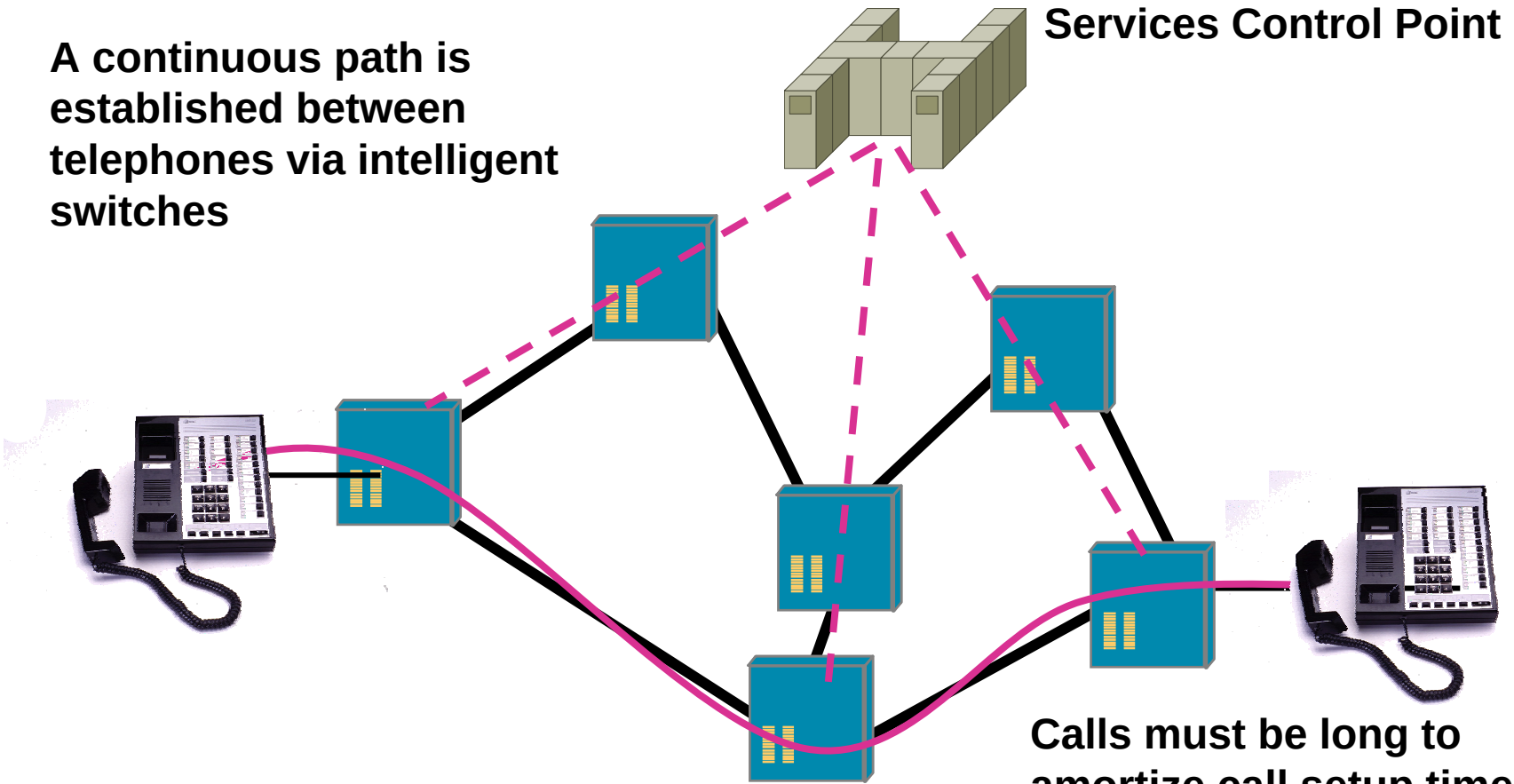
- Telephone networks are based on *circuits*
- A continuous path is established between telephones



© 2004 Marvin A. Sirbu

Circuit Switching

A continuous path is established between telephones via intelligent switches



Calls must be long to amortize call setup time

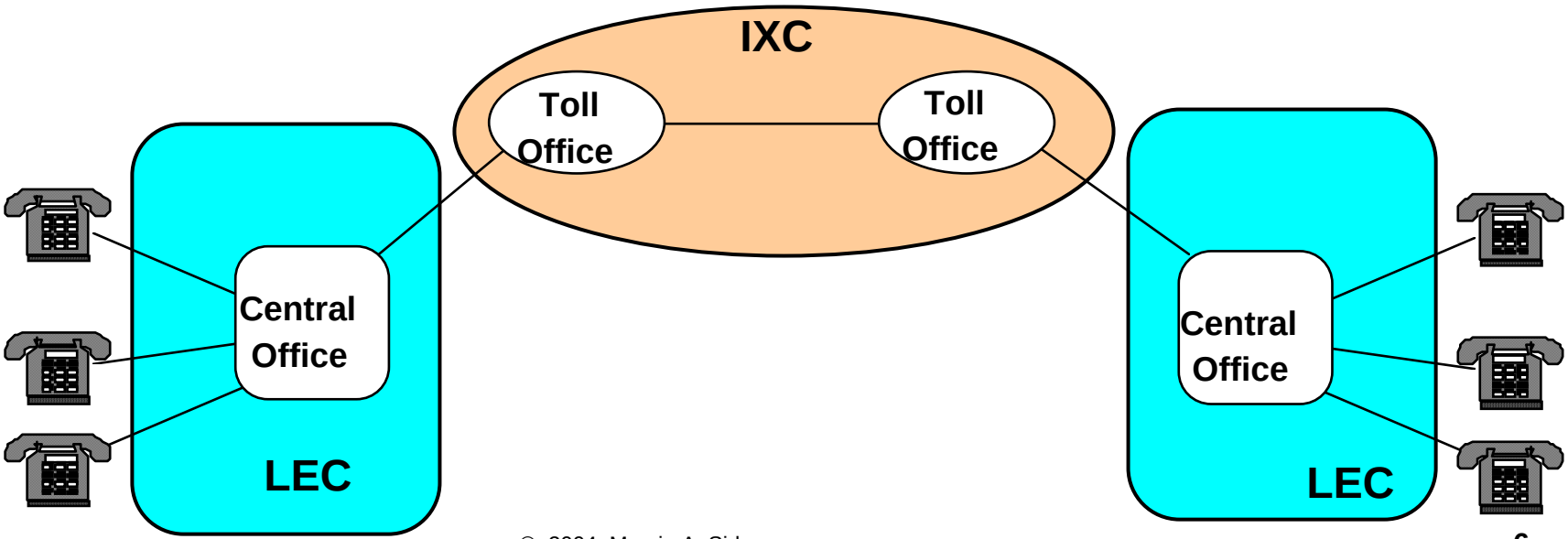
Circuit Switching

- The endpoints (telephone handsets) are dumb
- Copper wires connect endpoints to smart switches
- All the intelligence is in the network
- Services (call routing, voicemail, caller ID) are all provided by intelligence inside the network

© 2004 Marvin A. Sirbu

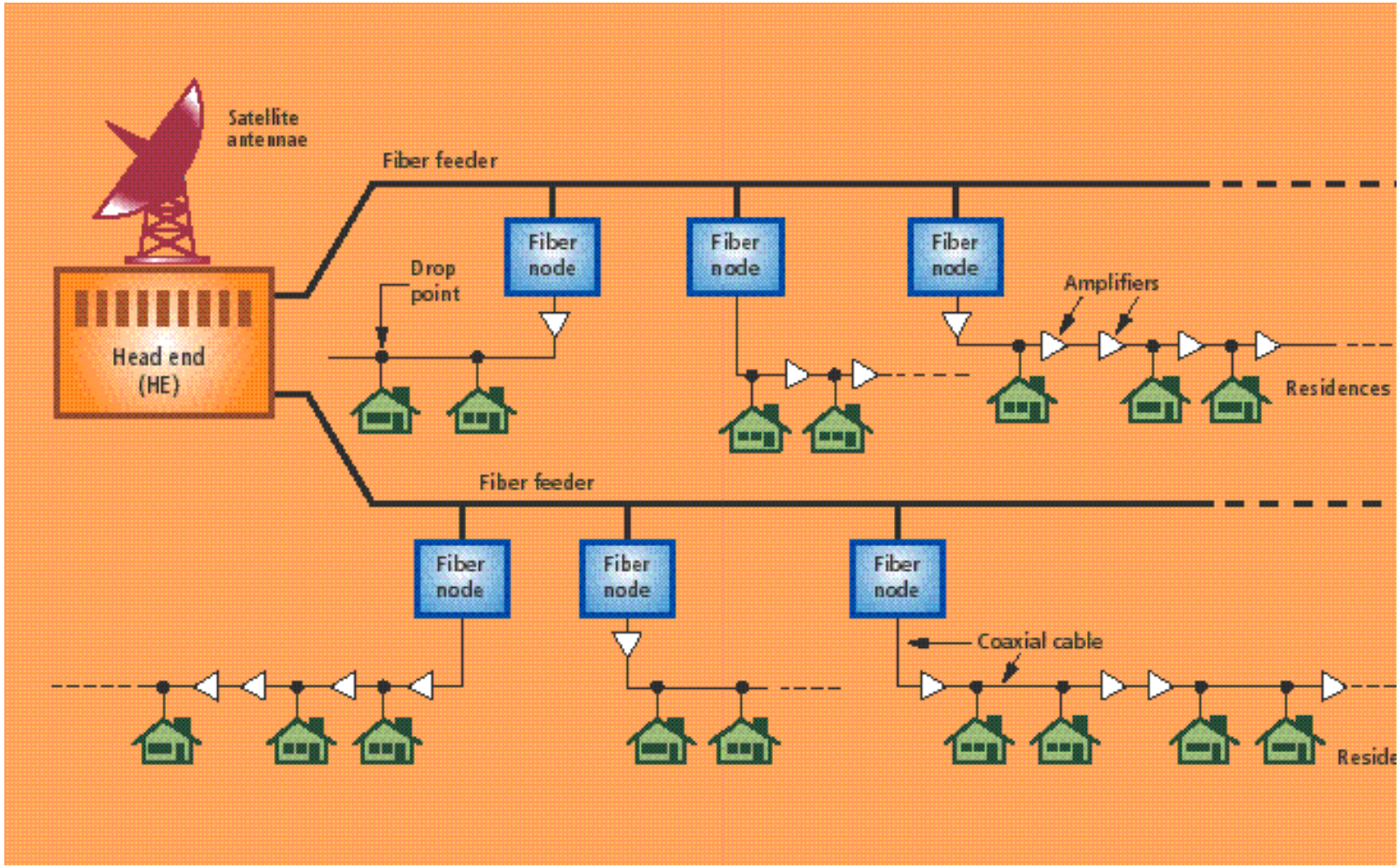
Regulation for telephony

- "Telecommunications": carriage of information of the customer's choosing without change end to end
- "Telephone Exchange Service" and "Telecommunications Service" defined by law and regulated by FCC and by States



© 2004 Marvin A. Sirbu

Modern Hybrid Fiber/Coax CATV Plant Architecture



Source: Dutta-Roy, "Cable: It's Not Just for TV," *IEEE Spectrum*, May, 1999

© 2004 Marvin A. Sirbu

Cable Television

- Started as retransmission of over-the-air broadcast
  - One-to-many communications
- Additional channels delivered to cable headend via satellite
- Regulated as “ancillary to broadcasting”
  - Must carry rules
- Because uses public ROW, franchised by municipality in most states
  - Franchise fees
  - PEG channel requirements

© 2004 Marvin A. Sirbu

New Video Services over Cable Plant

- **Digital Video**
  - **Send up to 10 digital video channels in the same bandwidth as one analog channel**
  - **600+ channels**
- **Video on Demand**
  - **If a neighborhood node serves 500 homes, can assign a unique channel to each household**
  - **➔each household can watch a video program of their own choosing (Video on Demand)**

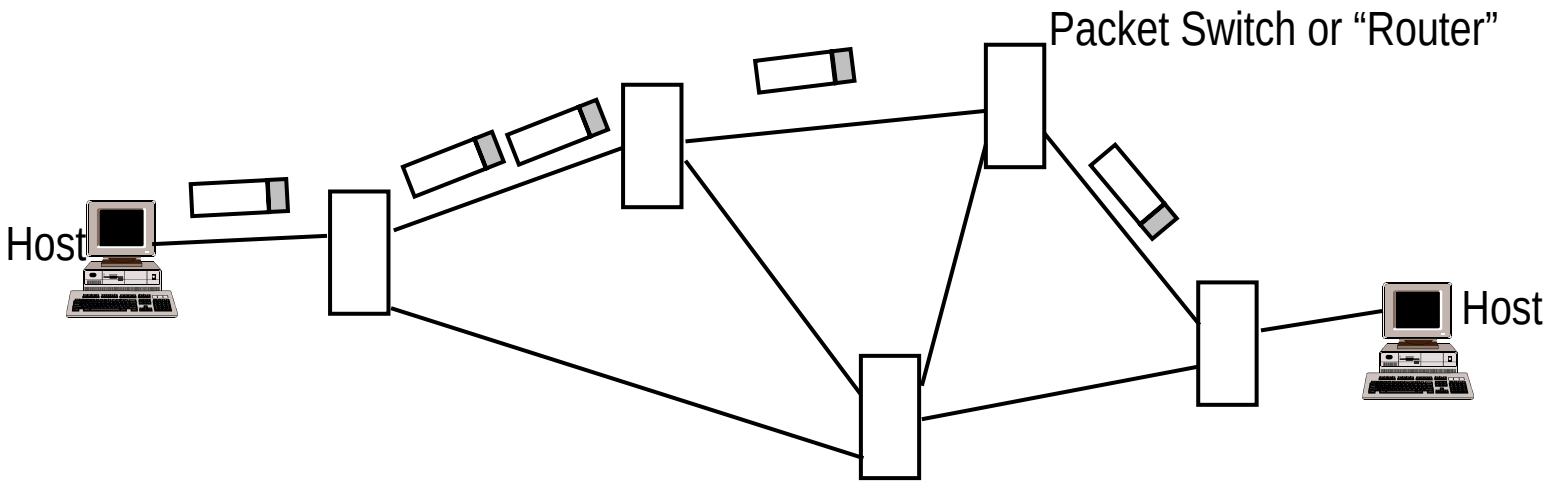
© 2004 Marvin A. Sirbu

The Evolution of Video

- Increasingly, consumers watch video at times of their own choosing
  - Tivo and Digital Video Recorders (DVR)
  - Video on Demand (VoD)
  - Movielink
  - Web-based streaming video
- Program selection is not limited to a defined number of channels
  - Video servers with thousands of programs

© 2004 Marvin A. Sirbu

Packet Switching

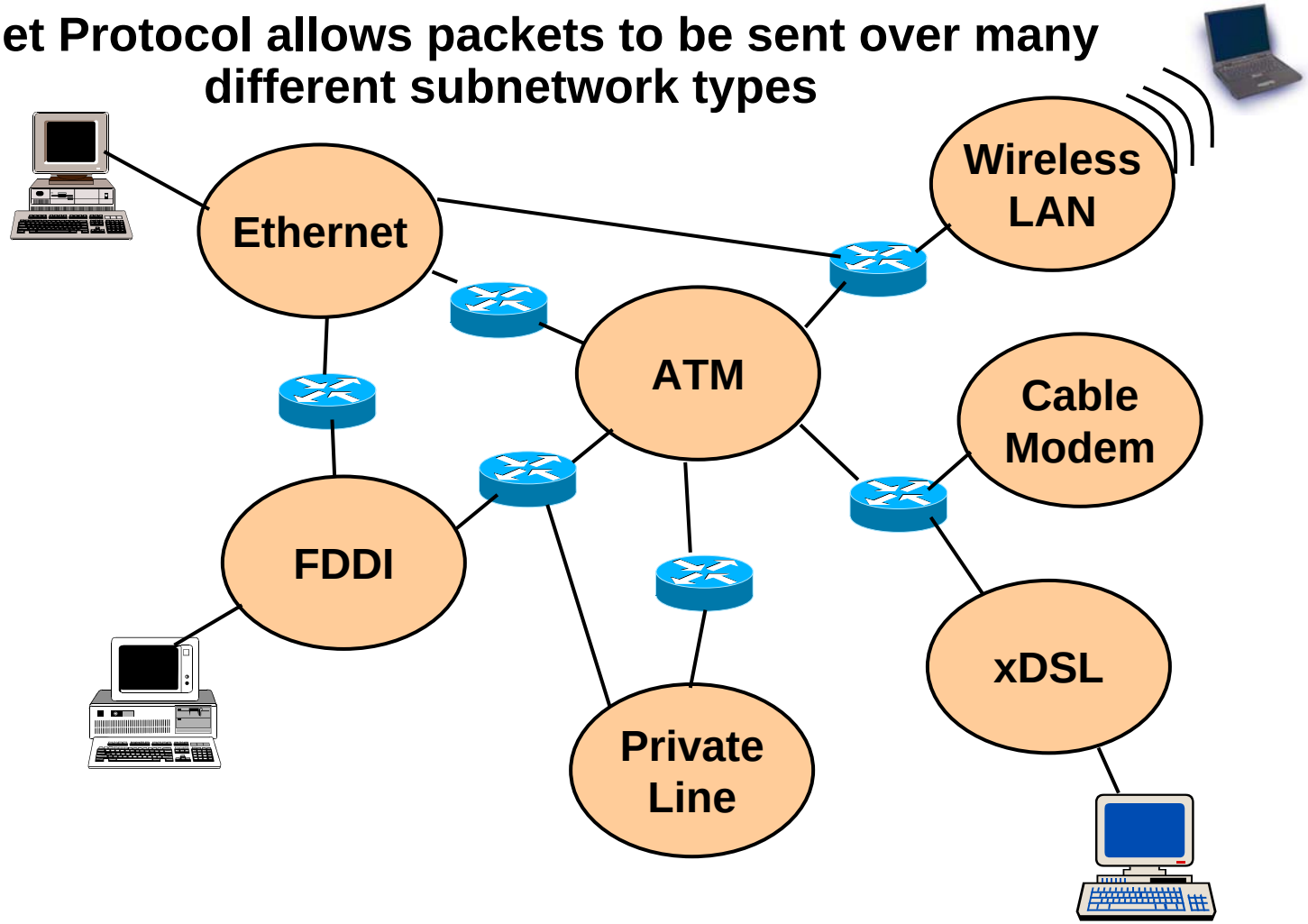


- **Information divided into chunks called “packets”**
- **Each packet of information carries address information in a header**
- **Packet switches route packets to destination**
- **Switches (routers) connected by direct links or by a subnetwork**

© 2004 Marvin A. Sirbu

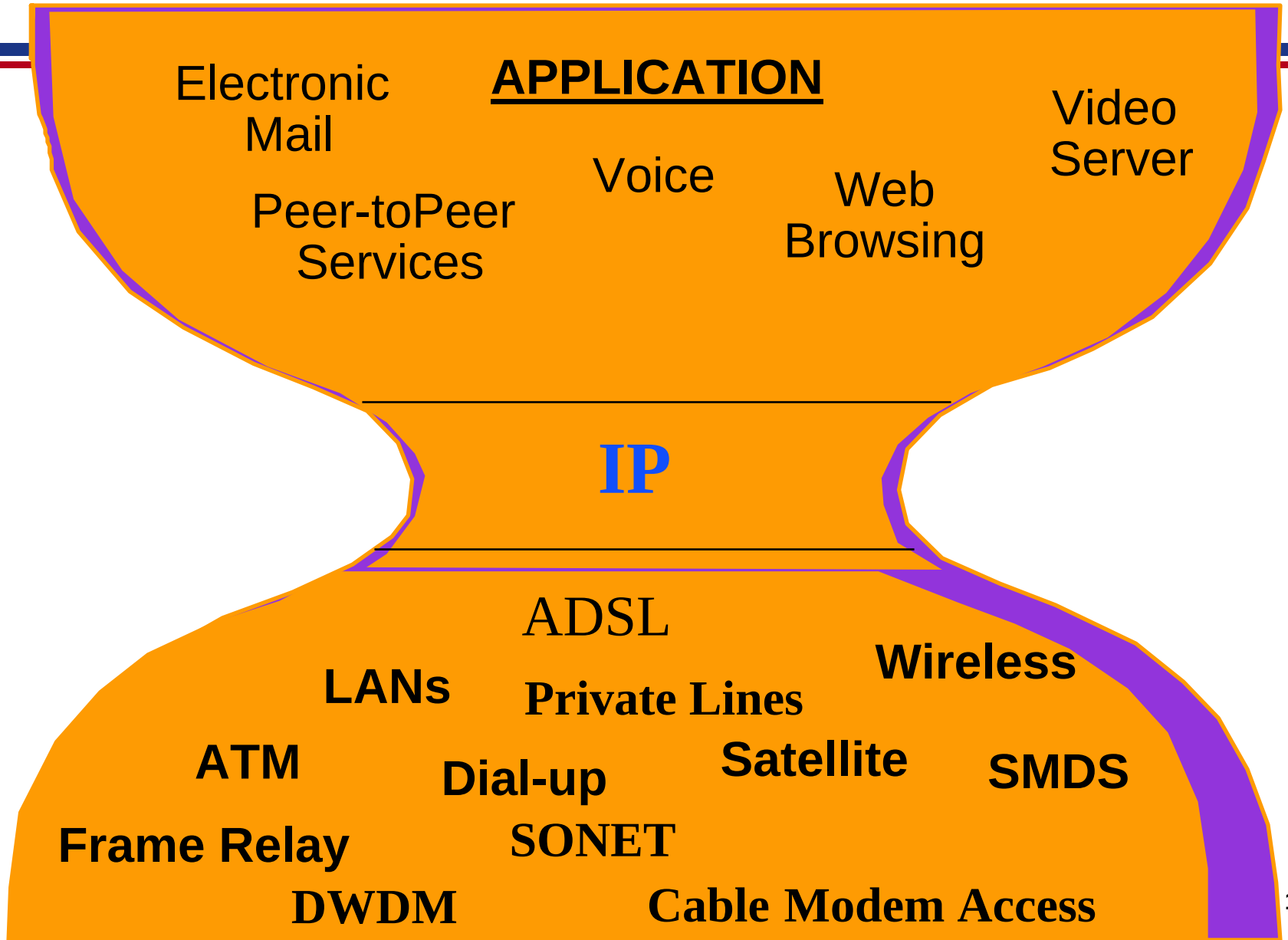
Internetworking

Internet Protocol allows packets to be sent over many different subnetwork types

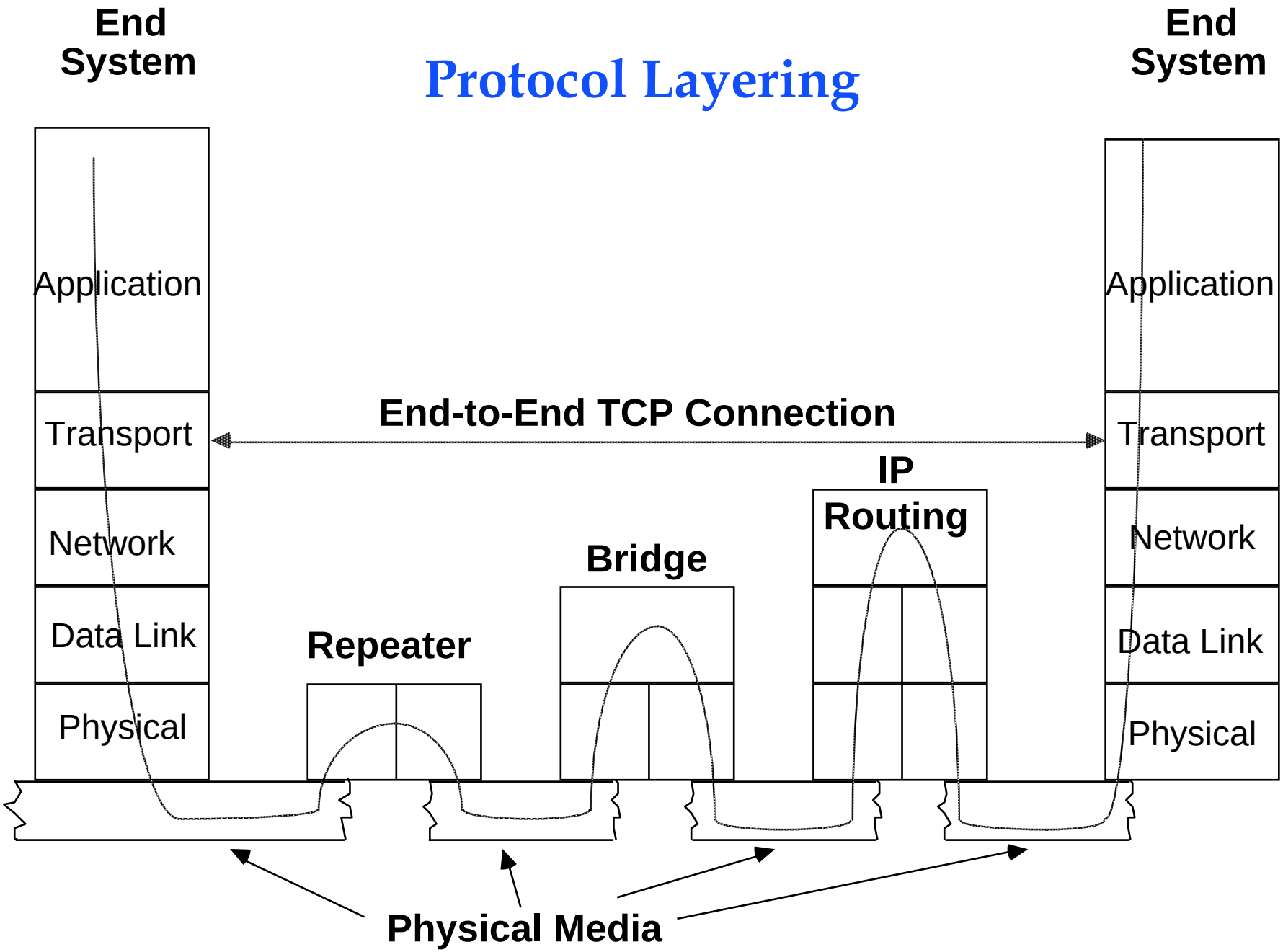


© 2004 Marvin A. Sirbu

Internet Architecture



Protocol Layering



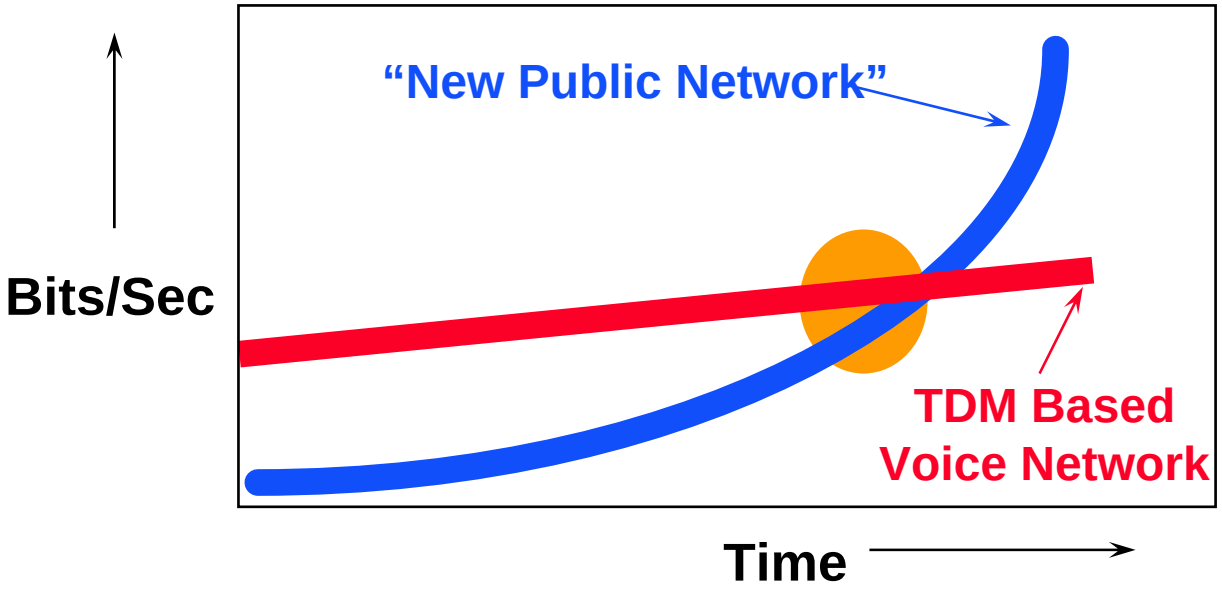
Internet Philosophy

- **Peer to Peer Network**
  - every Host able to communicate with every other host
- **End-to-end design principle**
  - Assume end systems are smart
  - Maximize functionality in the end systems
    - "stupid networks"
- **Internet Protocol provides "glue" for running over a variety of subnetwork types**
- **Network merely carries packets. Services are provided by applications running on Hosts**
  - Anybody can invent a new service
    - WWW
    - Napster
    - Net Meeting

© 2004 Marvin A. Sirbu

Data Now Drives Networking Architectures

- Network Architectures Have Been Voice Centric



- We used to build networks optimized for voice
  - Made data look like voice using a modem
- New networks are optimized for data
  - Make voice look like another type of data—Voice over IP

© 2004 Marvin A. Sirbu

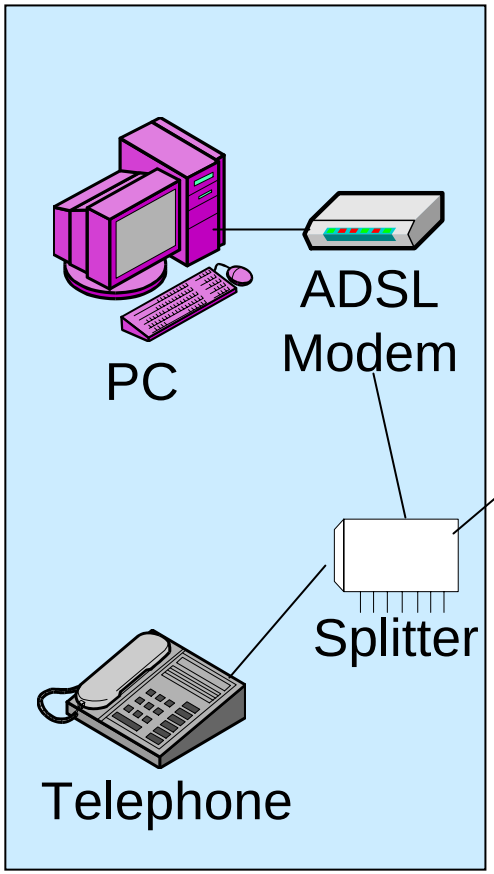
"Small" Broadband

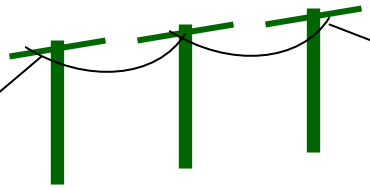
- **New Technologies provide broadband access to the home or small business at speeds up to 5 Mbps**
  - **DSL**
  - **Cable Modem**
  - **Fixed Wireless**
  - **3G and 4G Mobile Wireless**

© 2004 Marvin A. Sirbu

DSL from Central Office

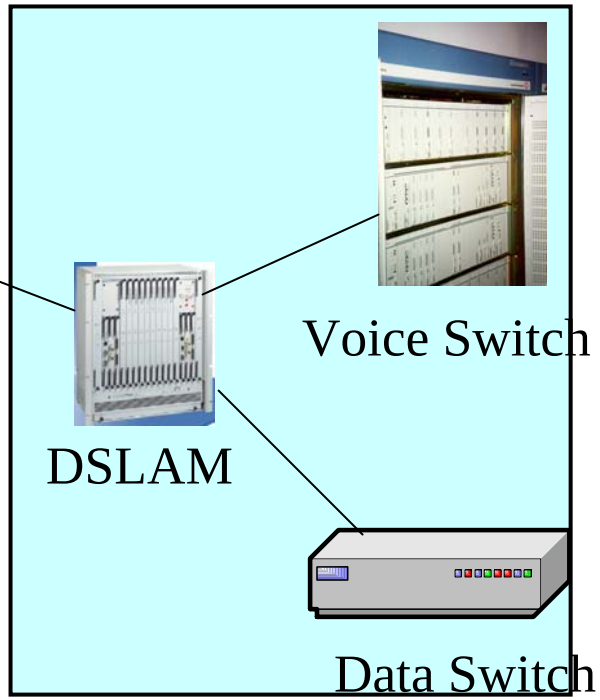
Subscriber Premises



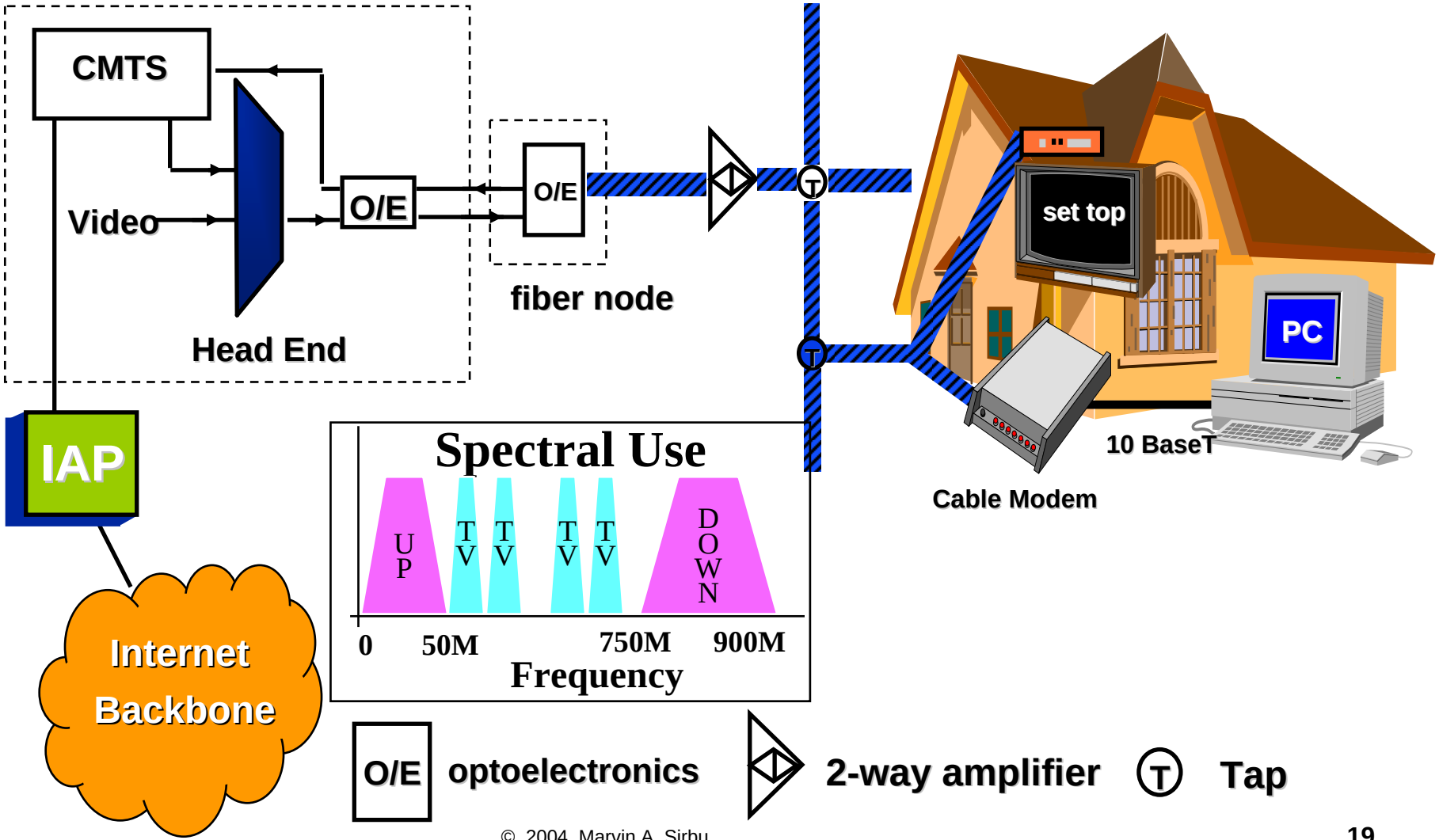


Data carried above
4KHz voice
frequencies

Central Office



Internet Access over Cable



Source: Stagg Newman

© 2004 Marvin A. Sirbu

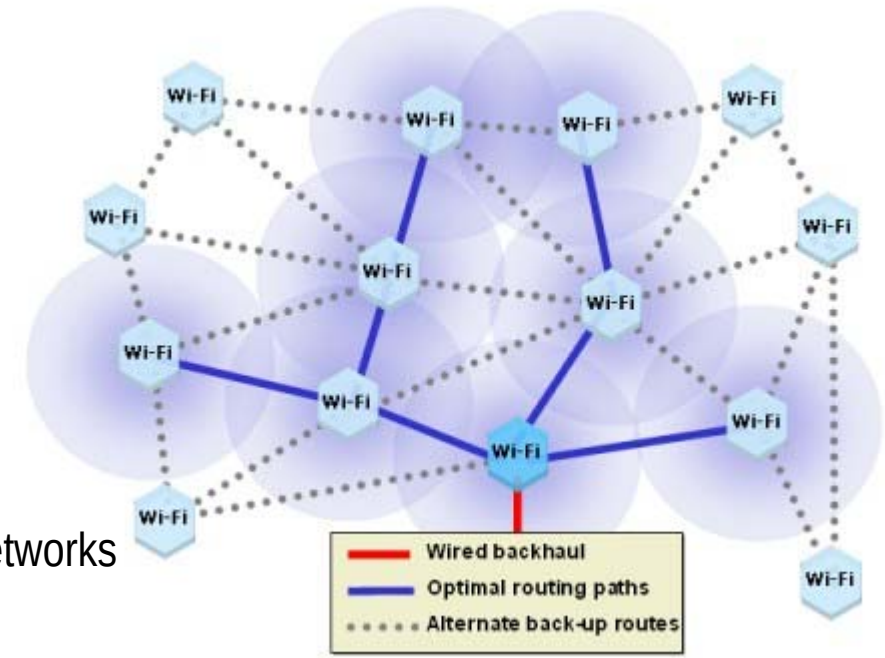
Fixed Wireless Broadband Access

- A single tower can cover up to 20 mile radius
- Rooftop antenna at subscriber premises
- New 802.16 (Wi-Max) standards promise low cost equipment beginning in 2005-2006

© 2004 Marvin A. Sirbu

Mesh Networks

- **Lots of small cells provide higher capacity per user**
  - **How to backhaul traffic from all the access points?**
- **A wireless *mesh* network uses APs as both leaf nodes, and transit nodes to carry traffic back towards the wired internet**



Source: Tropos Networks

Broadband Wireless Industry Trends

- **Standardization:**

  Proprietary physical layers giving way to few industry standards (3G, 802.11, 802.16). Driven by chip economics.

- **Trade-off between bit rate and reach & cost deploy**

  Rooftop antennas => high speed, long-reach

  Desktop antennas => inexpensive deployment (and need to address mobility => PC cards, PDAs, etc.)

- **Large cell v. Small cell**

  Large => long reach => few cells => wired backhaul

  Small => short reach => lots of cells => wireless backhaul or mesh

- **New designs include QoS capability (VoIP)**
- **Unlicensed v. Licensed**

  Unlicensed => rapid, low-cost entry for WISPs

  Licensed => better protection against congestion (QoS)

© 2004 Marvin A. Sirbu

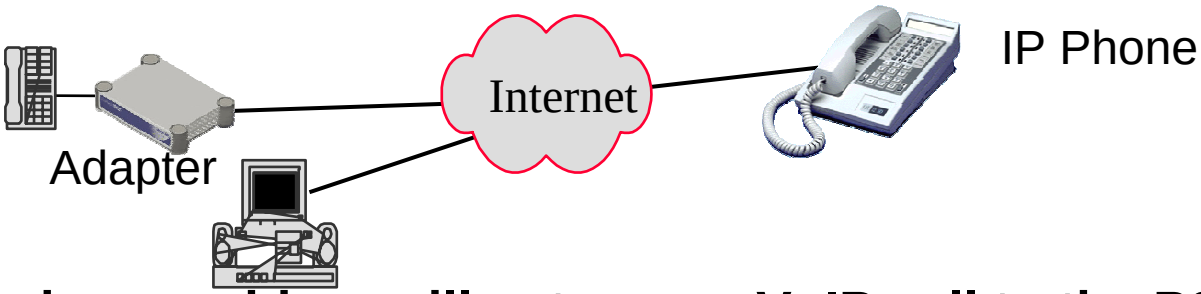
Moving Services over IP

- Voice over IP
- Video over IP

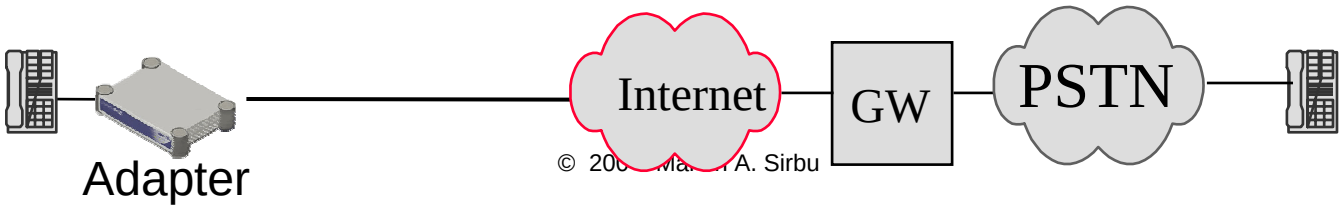
© 2004 Marvin A. Sirbu

Voice over IP

- Digitize speech and encode in packets
- If you have a broadband packet connection, you can send voice over it
  - Ordinary phone plus an adapter; or
  - IP Phone
- If recipient has a PC softphone, an IP phone or adapter, the call never touches the traditional PSTN



- Service providers will gateway a VoIP call to the PSTN

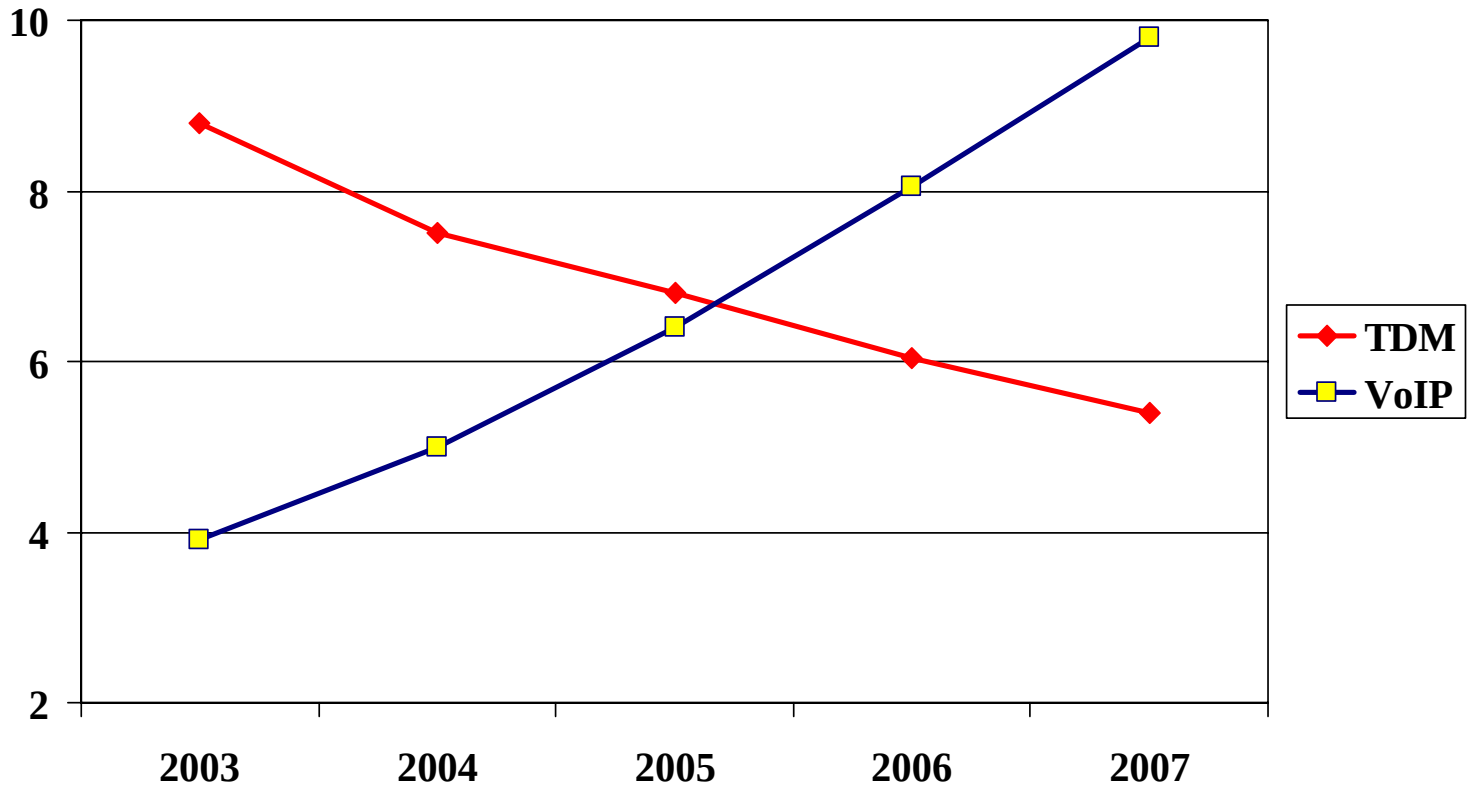


Telephony over Cable

- On an HFC plant, there is plenty of capacity for carrying voice traffic to each neighborhood.
- Early MSO investments were in circuit switched telephony over cable
- Beginning 2004, major deployments of VoIP by MSOs

© 2004 Marvin A. Sirbu

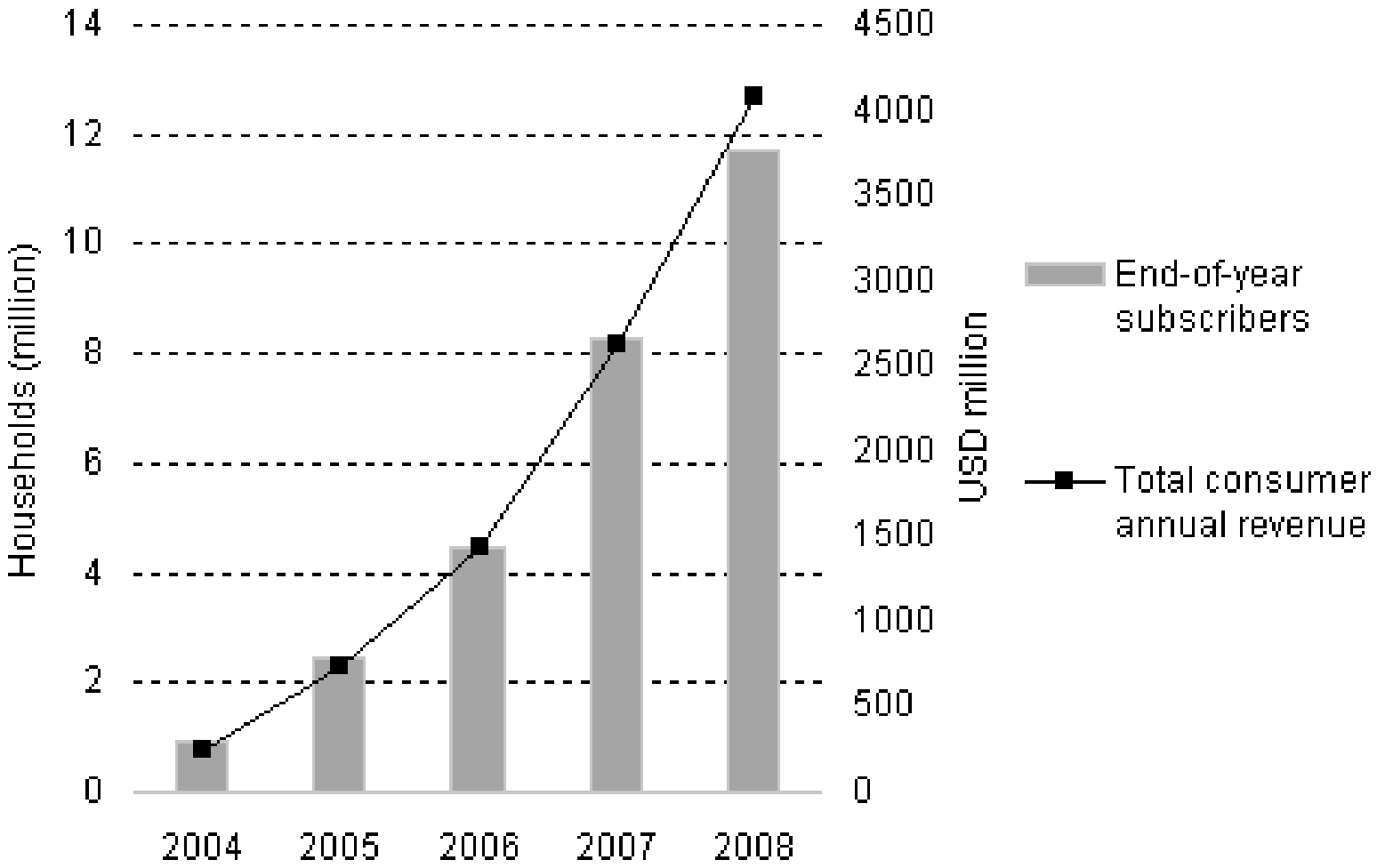
PBX Line Shipments by Technology



Source: *eWeek*, July 12, 2004, p. 43

© 2004 Marvin A. Sirbu

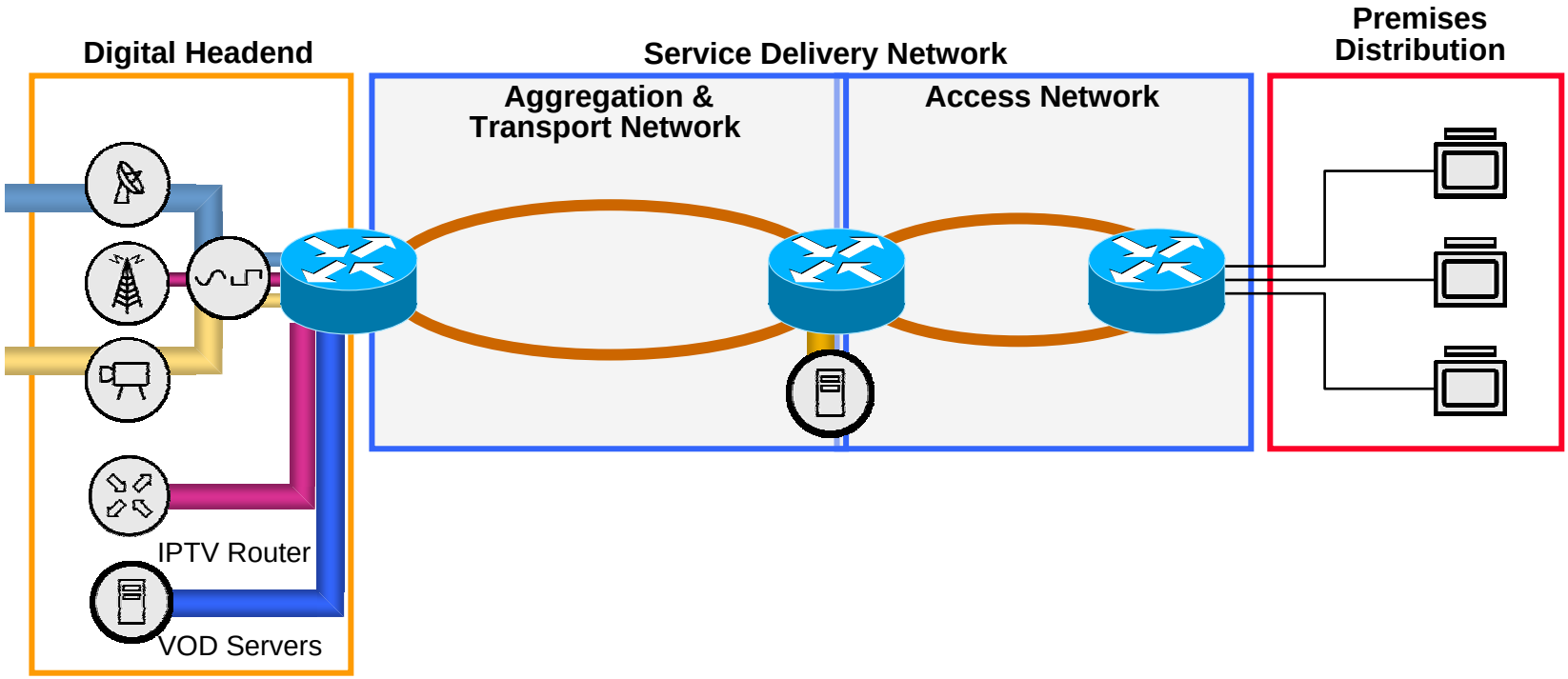
One Projection for VoIP Growth



© 2004 Marvin A. Sirbu

Video over IP

- Entertainment video can be delivered over a packet switched network
- Video becomes just another form of IP traffic



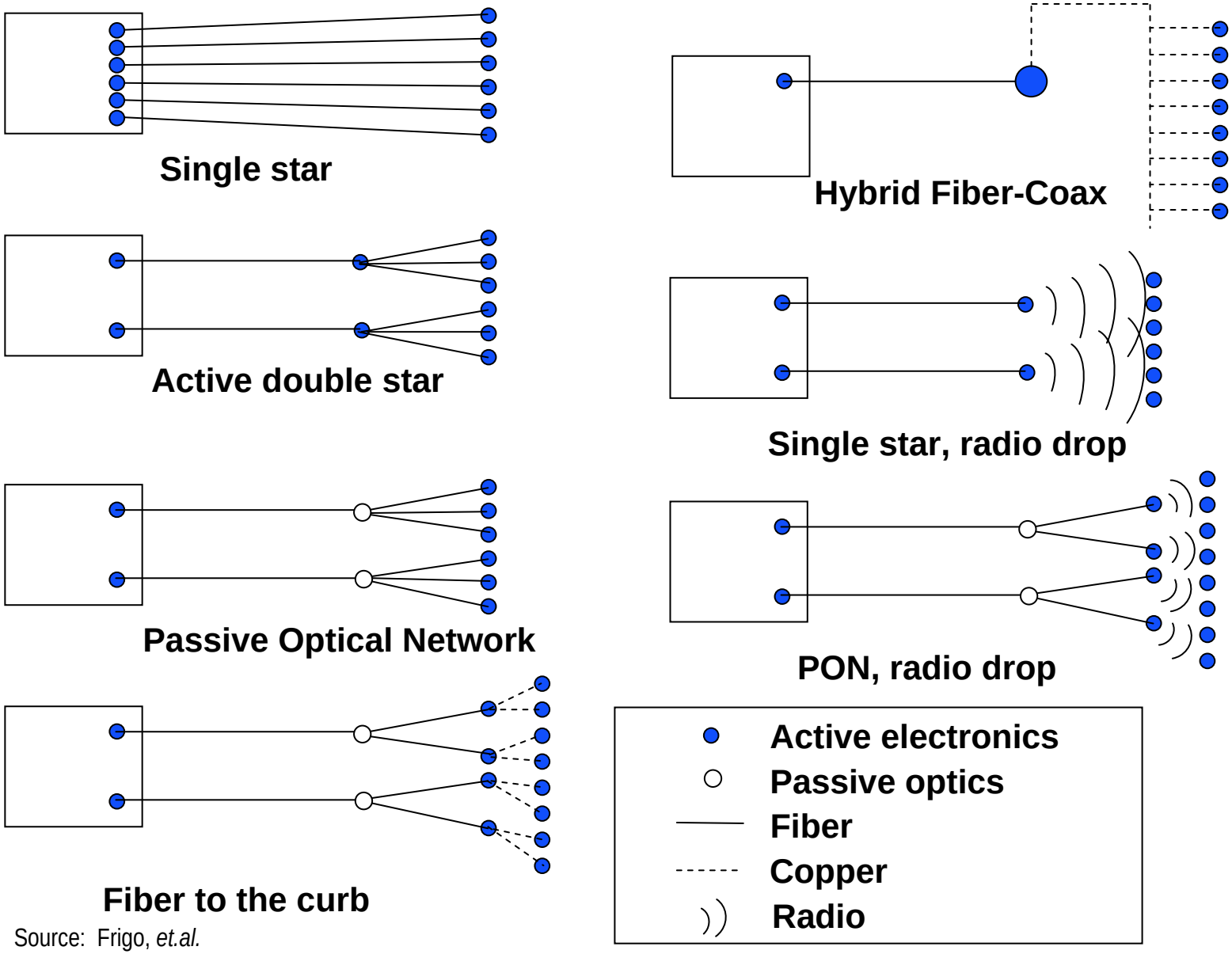
© 2004 Marvin A. Sirbu

" Big" Broadband

- To carry Video over IP need higher speed access networks
  - HDTV requires 10-18 Mbps for multiple channels per household
- To realize higher speeds, need to push fiber deeper into the neighborhood
  - Shorter copper drop ➔ higher speeds
  - Fewer homes per node ➔ higher speeds per home for cable modem
  - Higher speed wireless➔ shorter reach

© 2004 Marvin A. Sirbu

Broadband Local Access Alternatives



Source: Frigo, *et.al.*

Big Broadband Developments

- More than 1,000,000 FTTH customers in Japan
- Video over DSL being offered in Korea, Italy, Canada and Hong Kong
- Verizon announces intent to deploy million lines of FTTP/year
  - Deployments underway in Texas, California and Florida
- SBC announces intent to deploy Fiber-to-the-Node
  - Deep fiber to neighborhood allowing 20 Mbps DSL over remaining copper
- Bellsouth has a million lines of Fiber-to-the-curb

© 2004 Marvin A. Sirbu

The New Telecommunications

- **A single packet switched "big" broadband network will carry all services**
- **Telephony, video, computer gaming, are all simply applications over the network**
- **What kind of regulatory regime makes sense in this new environment?**
- **Do old categories make sense?**

  Telecommunications services* versus *information services

  Telephone exchange service

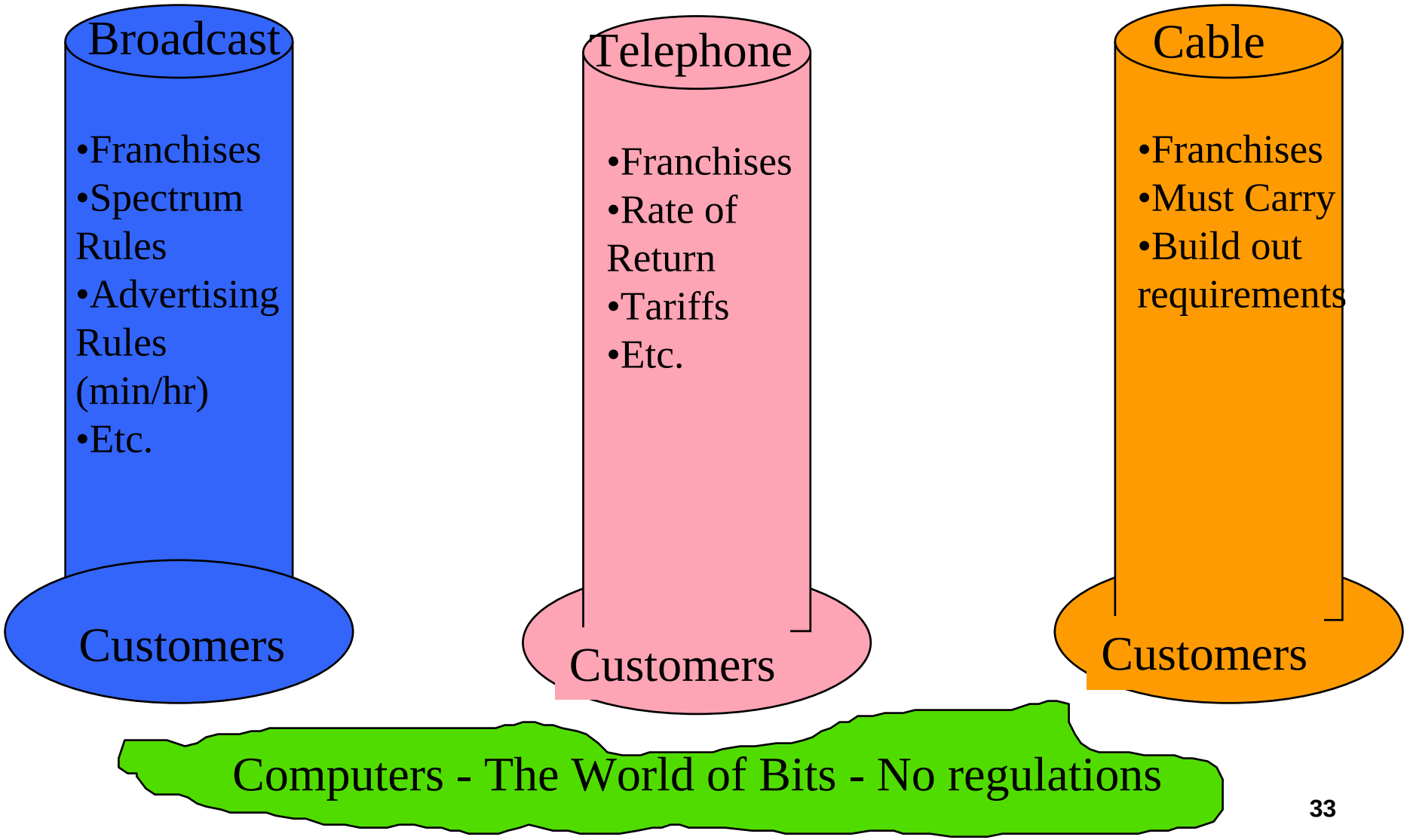
  Cable programming services

© 2004 Marvin A. Sirbu

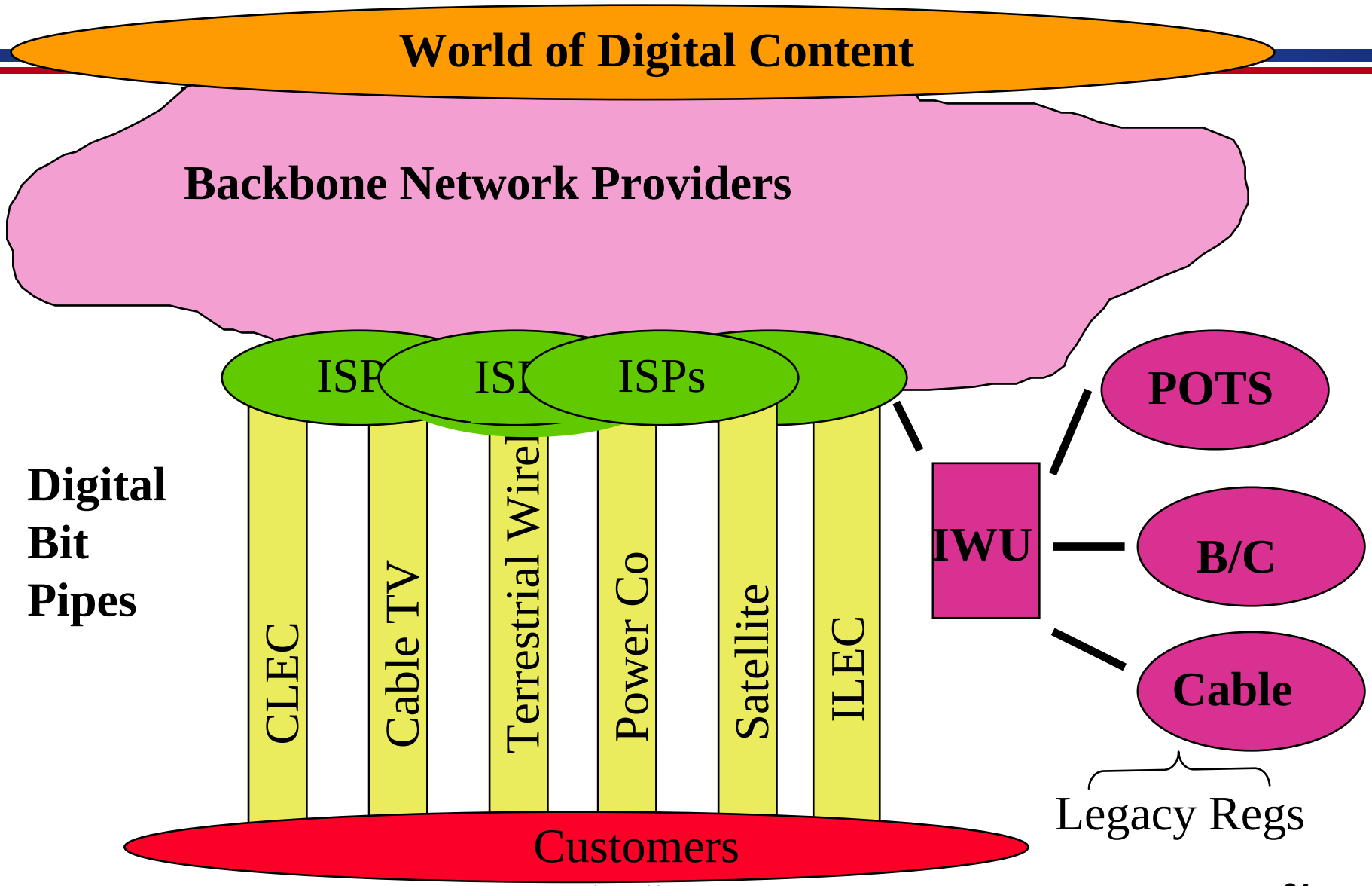
Carnegie Mellon

Regulation of Standalone Industries (Silos)
The regulatory regime circa 1995

(adapted from Stagg Newman, FCC)



Deregulator's Dream

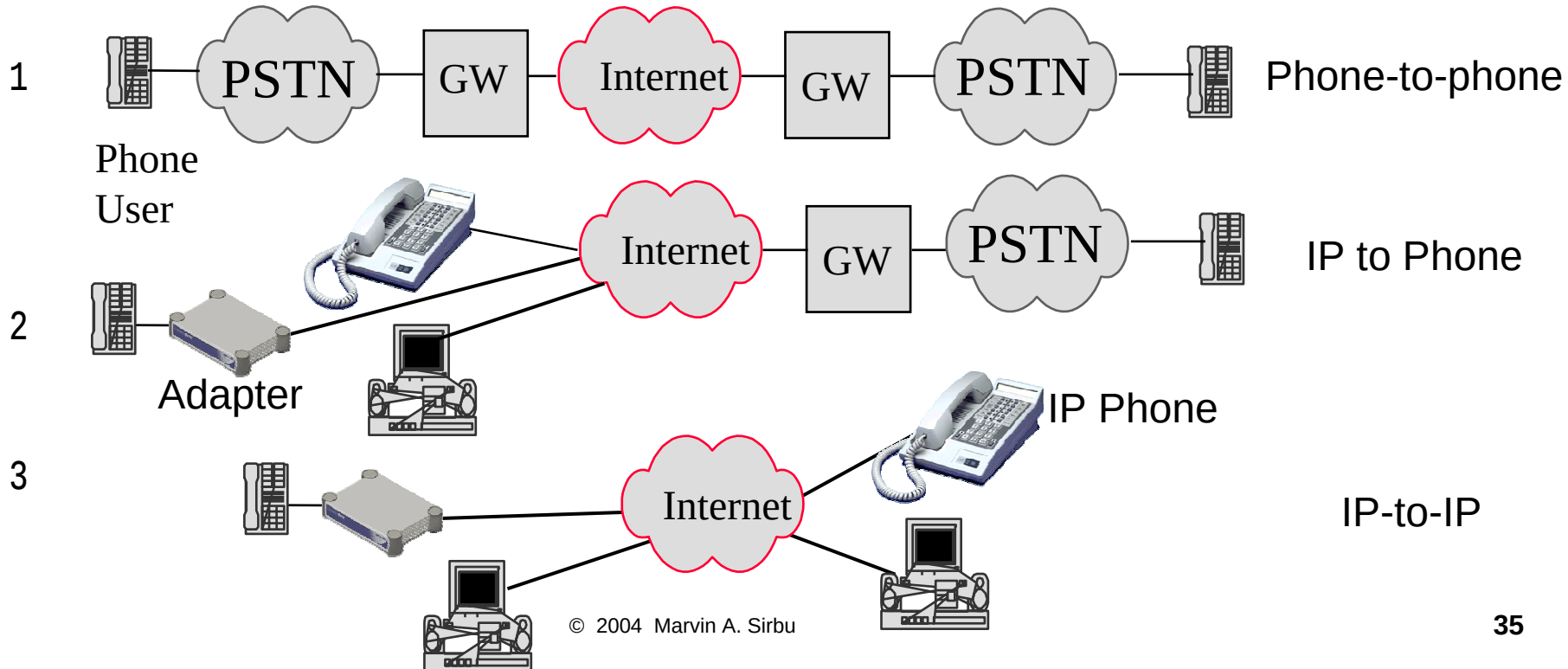


Source: Stagg Newman, FCC

© 2004 Marvin A. Sirbu

Regulating Voice over IP

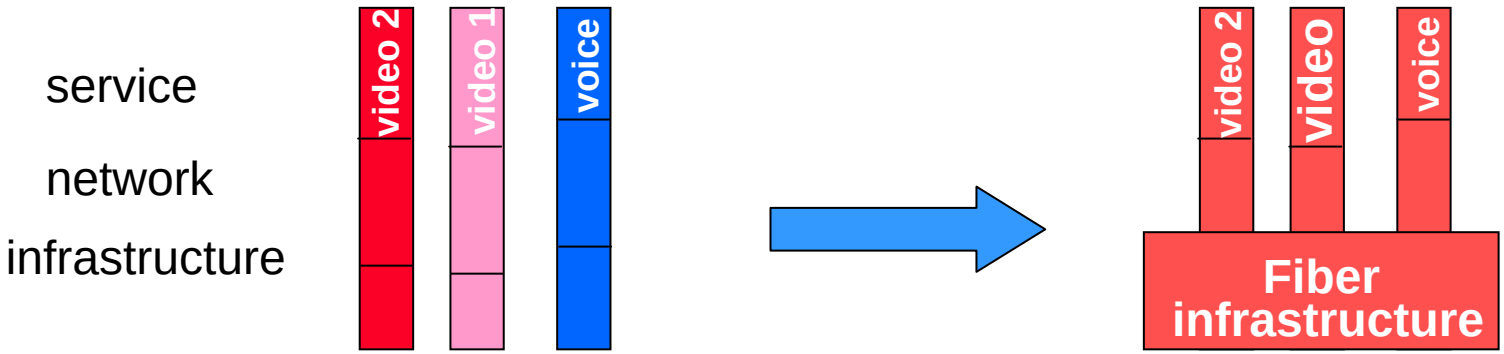
- **Three types of VoIP**
- **FCC says type 1 is regulated, type 3 is not**
- **What about Type 2?**
- **Eventually, everything will be type 3—and unregulated!**



© 2004 Marvin A. Sirbu

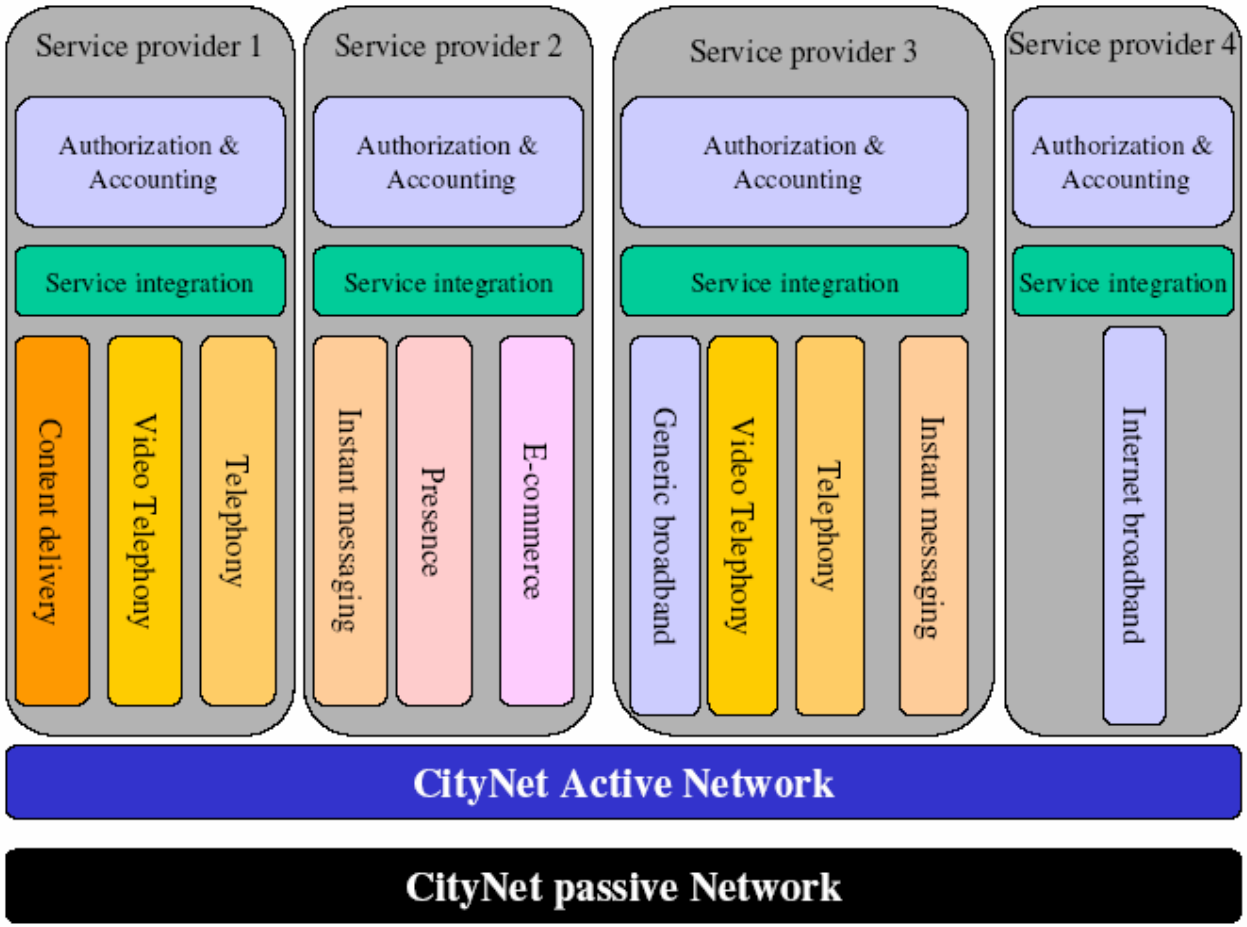
The Shift to An Integrated Broadband Infrastructure

- **A FTTx infrastructure will be able to support all services**
- **Will this lead to monopolization of services by the infrastructure owner?**



Broadband Infrastructure: The Role of Municipal Networks

- Can we decouple fiber and lower layer electronics (subnetwork) from higher layer services?
- Amsterdam Municipal Network Architecture



Implications of Competitive IP Video

- **When all Video is delivered as a packet switched stream, what happens to the concept of a *channel*?**
  - **Subscribers have access to unlimited content**
- **As subscribers switch to VoD, they may no longer being watching programs at a fixed time**
  - **Sports may be an exception**
- **If there are no longer *channels*, only *programs*, what happens to the concept of a PEG channel?**
  - **PEG content is just another program to be stored on the VoD server**
- **What leverage does a municipality have when infrastructure is decoupled from content with unregulated competitive service providers over the packet infrastructure?**

© 2004 Marvin A. Sirbu

Principles for a New Regulatory Framework

- **Common Carriage**

  Providers of physical layer telecommunications service should not discriminate on the basis of content or applications

- **Antitrust**

  Entities with market power at one layer (*e.g.* physical infrastructure) should not be allowed to use that power to reduce competition at other layers

- **Universal Service**

  In an era of converged services over broadband IP, Universal Service means having broadband access to the IP backbone

  All providers of access or backbone transport should contribute to Universal Service or application neutral taxes on traffic

- **Service specific features**

  In an Internet world where services are provided by software applications running on the endpoints, service specific features (*e.g.* E-911) imply constraints on consumer CPE or software. Requiring specific features in software or hardware must be balanced against limiting innovation in CPE

© 2004 Marvin A. Sirbu

Conclusions

- A transformation is underway from single purpose networks to general purpose broadband packet networks
- All services provided at the application layer by streams of packets from server to subscriber over the network
- This transformation challenges traditional regulatory frameworks and category definitions
- Municipalities may play a major role in the future with respect to physical infrastructure for broadband

© 2004 Marvin A. Sirbu

To Explore Further

- William Lehr, Marvin Sirbu & Sharon Gillett. (2004)."Municipal Wireless Broadband: Policy & Business Implications of Emerging Access Technologies," Draft paper, May 2004. Paper presented at London Business School Conference on Competition in wireless and wireline services, May 14, 2004 http://itc.mit.edu/itel/docs/2004/wlehr_munibb_doc.pdf
- William Lehr, Marvin Sirbu & Sharon Gillett. (2004). “Broadband Open Access: Lessons from Municipal Network Case Studies” http://web.si.umich.edu/tprc/papers/2004/333/Broadband_Open_Access.pdf
- Anupam Banerjee and Marvin Sirbu (2003), “" Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure", *32nd Telecommunications Policy Research Conference*, Arlington, Va., October, 2003 http://www.ini.cmu.edu/%7Esirbu/pubs/Banerjee_Sirbu.pdf

© 2004 Marvin A. Sirbu